IN THE CLAIMS

The following is a complete listing of the claims. This listing replaces all earlier versions and listings of the claims.

Claim 1 (currently amended): A method of operating an image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions, the method comprising the steps of:

(a) determining the viewing volume for each camera position;

(b) determining the volume bounded by the intersection of the viewing volumes; and

(c) setting the bounded volume as an initial space for use in deriving a representation of a three-dimensional surface of the object using [[said]] the images.

Claim 2 (currently amended): A method according to claim 1, further comprising the step [[(d)]] of (d) dividing the bounded volume into voxels to form an initial voxel space.

Claim 3 (original): A method according to claim 2, further comprising:

(e) determining, for each voxel that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is visible;

(f) comparing characteristics of each of the image areas corresponding to the same voxel;

(g) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent; and

(h) repeating steps (e) to (g) until all non-occluded voxels having inconsistent characteristics have been removed.

Claim 4 (original): In an image processing apparatus having a processor for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) determining the viewing volume for each camera position at which an image was taken;

(b) determining the volume bounded by the intersection of the viewing volumes;

(c) defining the bounded volume as an initial voxel space formed of voxels;

(d) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is represented;

(e) comparing characteristics of each of the image areas corresponding to the same voxel;

(f) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent; and

(g) repeating steps (d) to (f) until all non-occluded voxels having inconsistent characteristics have been removed.

Claim 5 (currently amended): A method according to claim 1, wherein the step of determining the viewing volume for a camera position ~~comprises~~ includes determining the viewing volume using data representing a camera focal point and a camera imaging area for that camera position.

Claim 6 (original): A method according to claim 5, wherein the step of determining the viewing volume includes projecting straight lines from the focal point through points on the boundary of the imaging area.

Claim 7 (original): A method according to claim 1, wherein the step of defining the intersection of the viewing volumes comprises (i) determining an initial intersection of the viewing volumes of first and second camera positions, (ii) determining the intersection of that intersection with another viewing volume and setting that intersection as the current intersection and (iii) repeating steps (i) and (ii) until the viewing volumes for all camera positions have been considered.

Claim 8 (currently amended): In an image processing apparatus having a processor for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining a volume containing the object as an initial space formed of voxels;

(b) accessing data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the same voxel;

(e) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent thereby producing a smaller voxel volume;

(f) repeating steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space;

(g) accessing data representing a further image of the object recorded at a different camera position from the first set of images;

(h) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in the further image;

(i) comparing the characteristic of the image area of the further image with the characteristic already associated with that voxel;

(j) removing a voxel in response to an inconsistency in the compared characteristics, thereby producing a smaller voxel space; and

(k) repeating steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a modified representation of the three-dimensional object surface.

Claim 9 (original): A method according to claim 8, which further comprises repeating steps (g) to (k) for each of a series of further images.

Claim 10 (original): A method according to claim 8 or 9, which further comprises discarding the first set of images after step (f).

Claim 11 (currently amended): A method according to claim 8, which comprises carrying out steps (g) to (j) by:

accessing data representing a number of further images of the object recorded at different camera positions from one another and the first set of images at step (g);

determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each of the further images at step (h);

comparing the characteristics of the image areas of the further images with the characteristic already associated with that voxel at step (i); and

removing a voxel in response to an inconsistency in the compared characteristics thereby producing a smaller voxel space at step (j).

Claim 12 (currently amended): In an image processing apparatus having a processor for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining a volume containing the object as an initial voxel space formed of voxels;

(b) accessing data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the same voxel;

(e) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent, thereby producing a smaller voxel volume;

(f) repeating steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space;

(g) accessing data representing a second set of images consisting of a sub-set of the first set and a further image of the object recorded at a different camera position from the first set of images;

(h) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each of the second set of images;

(i) comparing the characteristics of the image areas in each of the second set of images;

(j) removing a voxel in response to an inconsistency in the compared characteristics, thereby producing a smaller voxel space; and

(k) repeating steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a modified representation of the three-dimensional object surface.

Claim 13 (original): A method according to claim 12, which further comprises repeating steps (g) to (k) for each of a series of further images and changing the second set of images accessed in step (g) with each repetition.

Claim 14 (original): A method according to claim 13, which comprises changing the second set of images at each repetition by adding a further image from the first set of images.

Claim 15 (original): A method according to claim 13, which comprises changing the second set of images at each repetition by discarding at least one of the sub-set of the first set and including in the second set the further image accessed at the previous step (g).

Claim 16 (canceled)

Claim 17 (currently amended): A method according to claim [[16]] 19, further comprising deciding that a sub-voxel does not form part of the three-dimensional surface and so should be removed if the sub-voxel does not ~~meets said~~ meet the at least one criterion.

Claim 18 (currently amended): A method according to claim [[16]] 19, further comprising repeating steps c, d and e for any sub-voxel that does not meet [[said]] the at least one criterion.

Claim 19 (currently amended): In an image processing apparatus having a processor for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of: ~~A method according to claim 16,~~

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) checking to see if a voxel meets at least one criterion by projecting that voxel into at least one of the images;

(d) dividing, if the voxel does not meet the at least one criterion, the voxel into subsidiary voxels; and

(e) checking to see if the subsidiary voxels meet at least one criterion by projecting the subsidiary voxels into at least one of the image,

wherein the at least one criterion comprises any one or more of the following:

1) ~~the colour~~ a color variance in a pixel patch to which the voxel projects in an image has a value lower than a predetermined value;

2) [[the]] a difference in ~~colour~~ color or average ~~colour~~ color between pixel patches to which the voxel projects in different images has a standard deviation less than a predetermined value; and

3) the voxel is not partially occluded by a voxel or subsidiary voxels of smaller size than the voxel.

Claim 20 (currently amended): In an image processing apparatus having a processor for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) determining the area corresponding to a given voxel in each image in which the voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the given voxel;

(e) deriving from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel[[.]]; and

(f) sub-dividing a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and repeating steps (c) to (e) for each subsidiary voxel.

Claim 21 (original): A method according to claim 20, further comprising:

(g) in response to a subsidiary voxel having a derived value exceeding a threshold value and a size greater than a minimum size, sub-dividing that subsidiary voxel into subsidiary voxels and repeating steps (c) to (e) for each subsidiary voxel of that subsidiary voxel; and

(h) removing any subsidiary voxel of the minimum size having a derived value exceeding the threshold value.

Claim 22 (original): A method according to claim 20, which comprises repeating steps (c) to (h) until the degree of inconsistency for all non-occluded voxels and subsidiary voxels is below a predetermined value.

Claim 23 (currently amended): In an image processing apparatus having a processor for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object which data provides a ~~colour~~ color value for each pixel of each image;

(c) determining the area corresponding to a voxel in each image in which the voxel is visible;

(d) determining a ~~colour~~ color space value for each pixel of each area where each ~~colour~~ color space value encompasses a range of pixel ~~colour~~ color values;

(e) comparing the ~~colour~~ color space values for each of the image areas corresponding to the same voxel; and

(f) removing the voxel only if the image areas do not share at least one ~~colour~~ color space value.

Claim 24 (currently amended): In an image processing apparatus having a processor for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) determining the area corresponding to a voxel in each image in which that voxel is visible;

(c) comparing characteristics of each of the image areas corresponding to the voxel[[;]] to derive a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the voxel, and when the derived value for a voxel exceeds a threshold value[[:]],

(i) sub-dividing the voxel into subsidiary voxels;

(ii) determining the region corresponding to each sub-voxel in each image in which that sub-voxel is visible;

(iii) comparing characteristics of the image regions; and

(iv) removing the voxel only if there is no set of regions which contains a region from each image and for which the characteristics are not inconsistent.

Claim 25 (currently amended): A method according to [[of]] claim 4, wherein the step of determining the area corresponding to a voxel in an image comprises projecting the voxel into each image.

Claim 26 (currently amended): A method according to claim 4, wherein the step of comparing the characteristics of the image areas or regions comprises comparing ~~colours~~ colors of the image areas or regions.

Claim 27 (original): A method according to claim 4, which further comprises outputting a signal carrying data defining the initial space or the voxel representation of the three-dimensional object surface.

Claim 28 (original): A method according to claim 4, which further comprises providing a computer storage medium storing data defining the initial space or the voxel representation of the three-dimensional object surface.

Claim 29 (original): A method according to claim 4, further comprising generating texture data for rendering onto the representation of the three-dimensional object surface.

Claim 30 (currently amended): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions, the apparatus comprising:

means for determining the viewing volume for each camera position;

means for determining the volume bounded by the intersection of the viewing volumes; and

means for setting the bounded volume as an initial space for use in deriving a representation of a three-dimensional surface of the object using [[said]] the images.

Claim 31 (currently amended): ~~Apparatus~~ An apparatus according to claim 30, further comprising means for dividing the bounded volume into voxels to form an initial voxel space.

Claim 32 (currently amended): ~~Apparatus~~ An apparatus according to claim 31, further comprising processor means operable:

(i) to determine, for each voxel that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is visible;

(ii) to compare characteristics of each of the image areas corresponding to the same voxel; and

(iii) to remove each non-occluded voxel having inconsistent image area characteristics so as to provide a representation of the three-dimensional object surface.

Claim 33 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

means for determining the viewing volume for each camera position at which an image was taken;

means for determining the volume bounded by the intersection of the viewing volumes;

means for dividing the bounded volume into voxels to form an initial voxel space; and

processor means operable:

(i) to determine, for a voxel that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is represented;

(ii) to compare characteristics of each of the image areas corresponding to the same voxel; and

(iii) to remove a voxel when the characteristics of the image areas corresponding to that voxel are inconsistent.

Claim 34 (currently amended): ~~Apparatus~~ An apparatus according to claim 30, wherein the means for determining the viewing volume for a camera position is arranged to determine the viewing volume using data representing a camera focal point and camera imaging area for that camera position.

Claim 35 (currently amended): ~~Apparatus~~ An apparatus according to claim 34, wherein means for determining the viewing volume includes means for projecting straight lines from the focal point through points on the boundary of the imaging area.

Claim 36 (currently amended): ~~Apparatus~~ An apparatus according to claim 30, wherein the means for defining the intersection of the viewing volumes is arranged (i) to determine an initial intersection of the viewing volumes of first and second camera positions, (ii) to determine the intersection of that intersection with another viewing volume and to set that intersection as the current intersection, and (iii) to repeat (i) and (ii) until the viewing volumes for all camera positions have been considered.

Claim 37 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

means for defining an initial volume containing the object as an initial space formed of voxels, and

processor means operable:

(i) to access data representing a first set of images of the object each recorded at a respective one of a number of different camera positions with respect to the object;

(ii) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(iii) to compare characteristics of each of the image areas corresponding to the same voxel to remove any voxel have inconsistent characteristics and to store the resulting voxel space as a representation of the three-dimensional object

surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space;

(iv) then to access data representing a further image of the object recorded at a different camera position from the first set of images;

(v) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in the further image;

(vi) to compare the characteristic of the image area in the further image with the characteristic already associated with that voxel;

(vii) to remove any voxel for which the characteristic of the image area of the further image is inconsistent with that already associated with that voxel; and

(viii) to store the resulting voxel space as modified representation of the three-dimensional object surface.

Claim 38 (currently amended): An apparatus according to claim 37 wherein [[the]] <u>said</u> processor means is operable to carry out steps (iv) to (viii) for each of a series of further images.

Claim 39 (currently amended): An apparatus according to claim 37, wherein [[the]] <u>said</u> processor means is operable to cause the first set of images to be discarded after the processor means has stored the resulting voxel space.

Claim 40 (currently amended): An apparatus according to claim 37, wherein [[the]] said processor means is operable to access data representing a plurality of further images and to carry out steps (iv) to (viii) using all of the further images.

Claim 41 (currently amended): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

means for defining an initial volume containing the object as an initial voxel space formed of voxels; and

processor means operable:

(i) to access data representing a first set of images of the object each recorded at a respective different one of a number of different camera positions with respect to the object;

(ii) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(iii) to compare characteristics of each of the image areas corresponding to the same voxel;

(iv) to remove any voxel having inconsistent characteristics and to store the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space;

(v) then to access data representing a second set of images consisting of a sub-set of the first set and a further image of the object recorded at a different camera position from the first set of images;

(vi) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the second set;

(vii) to compare the characteristics of the image areas of second set; and

(viii) to remove any voxel having inconsistent characteristics in the second set of images to store the resulting voxel space as an updated representation of the three-dimensional object surface.

Claim 42 (currently amended): ~~Apparatus~~ An apparatus according to claim 41, wherein [[the]] said processor means is operable repeat steps (v) to (viii) for each of a series of different sets of images.

Claim 43 (currently amended): ~~Apparatus~~ An apparatus according to claim 42, wherein [[the]] said processor means is operable to change the second set of images at each repetition by adding a further image not forming part of the first set of images.

Claim 44 (currently amended): ~~Apparatus~~ An apparatus according to claim 42, wherein [[the]] said processor means is operable to change the second set of images at

each repetition by discarding at least one of the sub-set of the first set of images and to include in the second set at least one newly accessed further image.

Claim 45 (canceled)

Claim 46 (currently amended): ~~Apparatus~~ An apparatus according to claim [[45]] 48, wherein [[the]] said processor means is operable to decide that a sub-voxel does not form part of the three-dimensional surface and so should be removed if the sub-voxel does not meets [[said]] the at least one criterion.

Claim 47 (currently amended): ~~Apparatus~~ An apparatus according to claim [[45]] 48, wherein [[the]] said processor means is operable to repeat c, d and e for any sub-voxel that does not meet [[said]] the at least one criterion.

Claim 48 (currently amended): In an image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

means for defining an initial volume containing the object surface as an initial space formed of voxels;

means for accessing data representing images of the object recorded at different camera positions with respect to the object; and

processor means operable:

(c) to check to see if a voxel meets at least one criterion by projecting that voxel into at least one of the images;

(d) if the voxel does not meet the at least one criterion, to divide the voxel into subsidiary voxels; and

(e) to check to see if the subsidiary voxels meets at least one criterion by projecting the subsidiary voxels into at least one of the images, ~~Apparatus according to claim 45,~~

wherein the at least one criterion comprises any one or more of the following:

[[4]] 1) the ~~colour~~ color variance in a pixel patch to which the voxel projects in an image has a value lower than a predetermined value;

[[5]] 2) the difference in ~~colour~~ color or average ~~colour~~ color between pixel patches to which the voxel projects in different images has a standard deviation less than a predetermined value; and

[[6]] 3) the voxel is not partially occluded by a voxel or subsidiary voxels of smaller size than the voxel.

Claim 49 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

means for defining an initial volume containing the object surface as an initial space formed of voxels;

means for accessing data representing images of the object recorded at different camera positions with respect to the object; and

processor means operable:

(i) to determine the area corresponding to a given voxel in each image in which the voxel is visible;

(ii) to compare characteristics of each of the image areas corresponding to the given voxel;

(iii) to derive from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(iv) to sub-divide a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and to repeat steps (i) to (iii) for each subsidiary voxel;

(v) in response to a subsidiary voxel having a derived value exceeding a threshold value and a size greater than a minimum size, to sub-divide that subsidiary voxel into subsidiary voxels and to repeat (i) to (iii) for each subsidiary voxel of that subsidiary voxel;

(vi) to remove any subsidiary voxel of the minimum size having a derived value exceeding the threshold value; and

(vii) to repeat (i) to (vi) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 50 (currently amended): ~~Apparatus~~ An apparatus according to claim 49, wherein [[the]] said processor means is operable to repeat (i) to (vi) until the degree of inconsistency for all non-occluded voxels is below a predetermined value.

Claim 51 (currently amended): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

means for defining an initial volume containing the object surface as an initial space formed of voxels;

means for accessing data representing images of the object recorded at different camera positions with respect to the object which data provides a ~~colour~~ color value for each pixel of each image; and

processor means operable:

(a) to determine the area corresponding to a voxel in each image in which that voxel is visible;

(b) to determine a ~~colour~~ color space value for each pixel of each area where each colour space value encompasses a range of pixel ~~colour~~ color values;

(c) to compare the ~~colour~~ color space values for each of the image areas corresponding to the same voxel; and

(d) to remove the voxel only if the image areas do not share at least one ~~colour~~ color space value.

Claim 52 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

means for defining an initial volume containing the object surface as an initial space formed of voxels;

means for accessing data representing images of the object recorded at different camera positions with respect to the object; and

processor means operable:

(a) to determine the area corresponding to a voxel in each image in which that voxel is visible;

(b) to compare characteristics of each of the image areas corresponding to the same voxel; and

(c) to derive from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the voxel and, when the derived value for a voxel exceeds a threshold value,

(i) to sub-divide the voxel into subsidiary voxels,

(ii) to determine the region corresponding to each sub-voxel in each image in which that sub-voxel is visible,

(iii) to compare characteristics of the image regions, and

(iv) to remove the voxel only if there is no set of regions which contains a region from each image and for which the characteristics are not inconsistent.

Claim 53 (currently amended): ~~Apparatus~~ An apparatus according to claim 30, wherein [[the]] said processor means is operable to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is represented or visible by projecting the voxel into the image.

Claim 54 (currently amended): ~~Apparatus~~ An apparatus according to claim 30, wherein [[the]] said processor means is operable to compare characteristics of each of the image areas corresponding to the same voxel by comparing the ~~colours~~ colors of each of the image areas.

Claim 55 (currently amended): ~~Apparatus~~ An apparatus according to claim 30, further comprising means for outputting a signal carrying data defining the initial space or the voxel representation of the three-dimensional object surface.

Claim 56 (currently amended): ~~Apparatus~~ An apparatus according to claim 30, further comprising means for providing a computer storage medium storing data defining the initial space or the voxel representation of the three-dimensional object surface.

Claim 57 (currently amended): ~~Apparatus~~ An apparatus according to claim 30, further including comparing means for generating texture data for rendering onto a representation of the three-dimensional object surface.

Claim 58 (currently amended): A method according to claim [[16]] 19, ~~which~~ further ~~comprises~~ comprising:

accessing data representing a further image of the object recorded at different camera position; and

then repeating steps of claim 19 using that further image.

Claim 59 (currently amended): A method according to claim [[16]] 19, ~~which~~ further ~~comprises~~ comprising:

accessing data representing a set of images consisting of a sub-set of the images accessed at step (b) and a further image of the object recorded at a different camera position; and

repeating steps of claim 19 using that set of images.

Claim 60 (currently amended): A method according to claim 8, ~~which comprises defining the initial space using a method as set out in claim 1~~ further comprising:

determining a viewing volume for each camera position;

determining the volume bounded by the intersection of the viewing volumes; and

setting the bounded volume as an initial space for use in deriving a representation of a three-dimensional surface of the object using the images.

Claim 61 (currently amended): ~~Apparatus~~ An apparatus according to claim 48, wherein [[the]] said processor means is also operable[[:]] to access data representing a further image of the object recorded at a different camera position and then to repeat steps set out in claim 48 using that further image.

Claim 62 (currently amended): ~~Apparatus~~ An apparatus according to claim 48, wherein [[the]] said processor means is also operable[[:]] to access data representing a set of images consisting of a sub-set of images previously accessed and a further image of the object recorded at a different camera position and then to repeat the steps set out in claim 48 using that set of images.

Claim 63 (currently amended): ~~Apparatus~~ An apparatus according to claim 48, wherein [[the]] said processor means is further operable:

to ~~define the initial space as set out in any one of claim 30~~ determine the viewing volume for each camera position;

to determine the volume bounded by the intersection of the viewing volumes; and

to set the bounded volume as an initial space for use in deriving a representation of the three-dimensional surface of the object using the images.

Claim 64 (currently amended): A storage medium carrying ~~processor implementable~~ processor-implementable instructions for causing processing means to carry out a method in accordance with claim 1.

Claim 65 (currently amended): A ~~signal carrying processor implementable~~ program product containing processor-implementable instructions for causing processing means to carry out a method in accordance with claim 1.

Claim 66 (currently amended): A storage medium carrying ~~processor implementable~~ processor-implementable instructions for causing processing means to become configured to form apparatus in accordance with claim 30.

Claim 67 (currently amended): A ~~signal carrying processor implementable~~ program product containing processor-implementable instructions for causing processing means to become configured to form apparatus in accordance with ~~any one of~~ claim 30.

Claim 68 (original): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, a method of processing the image data to derive a computer representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) determining the viewing volume for each camera position at which an image was taken;

(b) determining the volume bounded by the intersection of the viewing volumes;

(c) defining the bounded volume as an initial voxel space formed of voxels;

(d) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is shown;

(e) comparing characteristics of each of the image areas corresponding to the same voxel;

(f) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent; and

(g) repeating steps (d) to (f) until all non-occluded voxels having inconsistent characteristics have been removed.

Claim 69 (original): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and camera positions to generate the three-dimensional computer model, an improvement comprising processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) determining the viewing volume for each camera position at which an image was taken;

(b) determining the volume bounded by the intersection of the viewing volumes;

(c) defining the bounded volume as an initial voxel space formed of voxels;

(d) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is shown;

(e) comparing characteristics of each of the image areas corresponding to the same voxel;

(f) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent; and

(g) repeating steps (d) to (f) until all non-occluded voxels having inconsistent characteristics have been removed.

Claim 70 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising:

a processor configured by processor instructions to operate:

to determine the viewing volume for each camera position at which an image was taken;

to determine the volume bounded by the intersection of the viewing volumes;

to divide the bounded volume into voxels to form an initial voxel space;

to determine for a voxel that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is represented;

to compare characteristics of each of the image areas corresponding to the same voxel; and

to remove a voxel when the characteristics of the image areas corresponding to that voxel are inconsistent.

Claim 71 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions to operate:

to determine the viewing volume for each camera position at which an image was taken;

to determine the volume bounded by the intersection of the viewing volumes;

to divide the bounded volume into voxels to form an initial voxel space;

to determine, for a voxel that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is represented;

to compare characteristics of each of the image areas corresponding to the same voxel; and

to remove a voxel when the characteristics of the image areas corresponding to that voxel are inconsistent.

Claim 72 (original): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, a method of processing the image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining a volume containing the object as an initial space formed of voxels;

(b) accessing data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the same voxel;

(e) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent thereby producing a smaller voxel volume;

(g) accessing data representing a further image of the object recorded at a different camera position from the first set of images;

(h) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in the further image;

(i) comparing the characteristic of the image area of the further image with the characteristic already associated with that voxel; and

(j) removing a voxel in response to an inconsistency in the characteristics compared at step (i), thereby producing a smaller voxel space.

Claim 73 (original): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, a method of processing the image data to derive a computer representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining a volume containing the object as an initial space formed of voxels;

(b) accessing data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the same voxel;

(e) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent, thereby producing a smaller voxel volume;

(g) accessing data representing a second set of images consisting of a sub-set of the first set and a further image of the object recorded at a different camera position from the first set of images;

(h) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each of the second set of images;

(i) comparing the characteristics of the image areas in each of the second set of images; and

(j) removing a voxel in response to an inconsistency in the characteristics compared at step (i), thereby producing a smaller voxel space.

Claim74 (original): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) defining a volume containing the object as an initial space formed of voxels;

(b) accessing data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the same voxel;

(e) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent thereby producing a smaller voxel volume;

(g) accessing data representing a further image of the object recorded at a different camera position from the first set of images;

(h) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in the further image;

(i) comparing the characteristic of the image area of the further image with the characteristic already associated with that voxel; and

(j) removing a voxel in response to an inconsistency in the characteristics compared at step (i), thereby producing a smaller voxel space.

Claim 75 (original): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) defining a volume containing the object as an initial voxel space formed of voxels;

(b) accessing data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the same voxel;

(e) removing a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent thereby producing a smaller voxel volume;

(g) accessing data representing a second set of images consisting of a sub-set of the first set and at least one further image of the object recorded at a different camera position from the first set of images;

(h) determining, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each of the second set of images;

(i) comparing the characteristics of the image areas in each of the second set of images; and

(j) removing a voxel in response to an inconsistency in the characteristics compared at step (i), thereby producing a smaller voxel space.

Claim 76 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising:

a processor configured by processor instructions to operate:

(a) to define a volume containing the object as an initial space formed of voxels;

(b) to access data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) to determine for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the same voxel;

(e) to remove a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent thereby producing a smaller voxel volume;

(g) to access data representing a further image of the object recorded at a different camera position from the first set of images;

(h) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in the further image;

(i) to compare the characteristic of the image area of the further image with the characteristic already associated with that voxel;

(j) to remove a voxel in response to an inconsistency in the characteristics compared at step (i), thereby producing a smaller voxel space; and

(l) to store the resulting voxel space as an modified representation of the three-dimensional object surface.

Claim 77 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the

three-dimensional computer model, an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising:

a processor configured by processor instructions to operate:

(a) to define a volume containing the object as an initial voxel space formed of voxels;

(b) to access data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the same voxel;

(e) to remove a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent thereby producing a smaller voxel volume;

(g) to access data representing a second set of images consisting of a sub-set of the first set and a further image of the object recorded at a different camera position from the first set of images;

(h) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each of the second set of images;

(i) to compare the characteristics of the image areas in each of the second set of images;

(j) to remove a voxel in response to an inconsistency in the characteristics compared at step (i), thereby producing a smaller voxel space; and

(l) to store the resulting voxel space as an updated representation of the three-dimensional object surface.

Claim 78 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising:

a processor configured by processor instructions to operate:

(a) to define a volume containing the object as an initial space formed of voxels;

(b) to access data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) to determine for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the same voxel;

(e) to remove a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent thereby producing a smaller voxel volume;

(g) to access data representing a further image of the object recorded at a different camera position from the first set of images;

(h) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in the further image;

(i) to compare the characteristic of the image area of the further image with the characteristic already associated with that voxel;

(j) to remove a voxel in response to an inconsistency in the characteristics compared at step (i), thereby producing a smaller voxel space; and

(l) to store the resulting voxel space as an modified representation of the three-dimensional object surface.

Claim 79 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising:

a processor configured by processor instructions to operate:

(a) to define a volume containing the object as an initial voxel space formed of voxels;

(b) to access data representing a first set of images of the object each recorded at a different camera position with respect to the object;

(c) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the same voxel;

(e) to remove a voxel in response to the characteristics of the image areas corresponding to that voxel being inconsistent thereby producing a smaller voxel volume;

(g) to access data representing a second set of images consisting of a sub-set of the first set and a further image of the object recorded at a different camera position from the first set of images;

(h) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each of the second set of images;

(i) to compare the characteristics of the image areas in each of the second set of images;

(j) to remove a voxel in response to an inconsistency in the characteristics compared at step (i), thereby producing a smaller voxel space; and

(l) to store the resulting voxel space as an updated representation of the three-dimensional object surface.

Claim 80 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, a method of processing the image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) checking to see if a voxel meets at least one criterion by projecting that voxel into at least one of the images;

(d) if the voxel does not meet [[said]] <u>the</u> at least one criterion, dividing the voxel into subsidiary voxels; and

(e) then checking to see if the subsidiary voxels meets at least one criterion by projecting the subsidiary voxels into at least one of the images,

<u>wherein the at least one criterion comprises any one or more of the following:</u>

<u>1) a color variance in a pixel patch to which the voxel projects in an image having a value lower than a predetermined value;</u>

2) a difference in color or average color between pixel patches to which the voxel projects in different images having a standard deviation less than a predetermined value; and

3) the voxel is not partially occluded by a another voxel or subsidiary voxels of a smaller size than the voxel.

Claim 81 (original): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, a method of processing the image data to derive a representation of a three-dimensional surface of the object, the method comprising the steps of:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) determining the area corresponding to a given voxel in each image in which the voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the given voxel;

(e) deriving from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(f) sub-dividing a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and repeating steps (c) to (e) for each subsidiary voxel;

(g) in response to a subsidiary voxel having a derived value exceeding a threshold value and a size greater than a minimum size, sub-dividing that subsidiary voxel into subsidiary voxels and repeating steps (c) to (e) for each subsidiary voxel of that subsidiary voxel;

(h) removing any subsidiary voxel of the minimum size having a derived value exceeding the threshold value; and

(i) repeating steps (c) to (h) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 82 (currently amended): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object; and

(c) determining the area corresponding to a given voxel in each image in which that voxel is visible.

Claim 83 (original): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) determining the area corresponding to a given voxel in each image in which the voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the given voxel;

(e) deriving from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(f) sub-dividing a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and repeating steps (c) to (e) for each subsidiary voxel;

(g) in response to a subsidiary voxel having a derived value exceeding a threshold value and a size greater than a minimum size, sub-dividing that subsidiary voxel into subsidiary voxels and repeating steps (c) to (e) for each subsidiary voxel of that subsidiary voxel;

(h) removing any subsidiary voxel of the minimum size having a derived value exceeding the threshold value; and

(i) repeating steps (c) to (h) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 84 (original): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, a method for processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) determining the area corresponding to a given voxel in each image in which that voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the given voxel;

(e) deriving from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(f) sub-dividing a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and repeating steps (c) to (e) for each subsidiary voxel;

(g) removing any subsidiary voxel having a derived value exceeding a threshold value; and

(h) repeating steps (c) to (g) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 85 (original): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and the camera positions to generate the three-dimensional computer model, a method for processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) determining the area corresponding to a given voxel in each image in which the voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the given voxel;

(e) deriving from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(f) sub-dividing a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and repeating steps (c) to (e) for each subsidiary voxel;

(g) in response to a subsidiary voxel having a derived value exceeding a threshold value and a size greater than a minimum size, sub-dividing that subsidiary voxel into subsidiary voxels and repeating steps (c) to (e) for each subsidiary voxel of that subsidiary voxel;

(h) removing any subsidiary voxel of the minimum size having a derived value exceeding the threshold value; and

(i) repeating steps (c) to (h) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 86 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions to operate:

(a) to define an initial volume containing the object surface as an initial space formed of voxels;

(b) to access data representing images of the object recorded at different camera positions with respect to the object;

(c) to check to see if a voxel meets at least one criterion by projecting that voxel into at least one of the images;

(d) if the voxel does not meet [[said]] the at least one criterion, to divide the voxel into subsidiary voxels; and

(e) then to check to see if the subsidiary voxels meets at least one criterion by projecting the subsidiary voxels into at least one of the images,

wherein the at least one criterion comprises any one or more of the following:

1) a color variance in a pixel patch to which the voxel projects in an image having a value lower than a predetermined value;

2) a difference in color or average color between pixel patches to which the voxel projects in different images having a standard deviation less than a predetermined value; and

3) the voxel is not partially occluded by a another voxel or subsidiary voxels of a smaller size than the voxel.

Claim 87 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions:

(a) to define an initial volume containing the object surface as an initial space formed of voxels;

(b) to access data representing images of the object recorded at different camera positions with respect to the object;

(c) to determine the area corresponding to a given voxel in each image in which the voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the given voxel;

(e) to derive from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(f) to sub-divide a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and repeating steps (c) to (e) for each subsidiary voxel;

(g) in response to a subsidiary voxel having a derived value exceeding a threshold value and a size greater than a minimum size, to sub-divide that subsidiary voxel into subsidiary voxels and to repeat steps (c) to (e) for each subsidiary voxel of that subsidiary voxel;

(h) to remove any subsidiary voxel of the minimum size having a derived value exceeding the threshold value; and

(i) to repeat steps (c) to (h) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 88 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising an apparatus for processing image data representing images of an object taken from a plurality of different

camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions to operate:

(a) to define an initial volume containing the object surface as an initial space formed of voxels;

(b) to access data representing images of the object recorded at different camera positions with respect to the object;

(c) to determine the area corresponding to a given voxel in each image in which that voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the given voxel;

(e) to derive from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(f) to sub-divide a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and to repeat steps (c) to (e) for each subsidiary voxel;

(g) to remove any subsidiary voxel having a derived value exceeding a threshold value; and

(h) to repeat steps (c) to (g) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 89 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising an apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions:

(a) to define an initial volume containing the object surface as an initial space formed of voxels;

(b) to access data representing images of the object recorded at different camera positions with respect to the object;

(c) to determine the area corresponding to a given voxel in each image in which the voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the given voxel;

(e) to derive from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(f) to sub-divide a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and repeating steps (c) to (e) for each subsidiary voxel;

(g) in response to a subsidiary voxel having a derived value exceeding a threshold value and a size greater than a minimum size, to sub-divide that subsidiary voxel into subsidiary voxels and to repeat steps (c) to (e) for each subsidiary voxel of that subsidiary voxel;

(h) to remove any subsidiary voxel of the minimum size having a derived value exceeding the threshold value; and

(i) to repeat steps (c) to (h) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 90 (currently amended): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and camera positions to generate the three-dimensional computer model, an improvement comprising processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) determining the area corresponding to a given voxel in each image in which that voxel is visible;

(d) determining a ~~colour~~ color space value for each pixel of each area where each ~~colour~~ color space value encompasses a range of pixel ~~colour~~ color values;

(e) comparing the ~~colour~~ color space values for each of the image areas corresponding to the same voxel; and

(f) removing the voxel only if the image regions do not share at least one ~~colour~~ color space value.

Claim 91 (currently amended): In a method of processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and using the images and camera positions to generate the three-dimensional computer model, an improvement comprising processing the image data to derive a computer representation of a three-dimensional surface of the object by:

(a) defining an initial volume containing the object surface as an initial space formed of voxels;

(b) accessing data representing images of the object recorded at different camera positions with respect to the object;

(c) determining the area corresponding to a voxel in each image in which that voxel is visible;

(d) comparing characteristics of each of the image areas corresponding to the same voxel; and

(e) deriving from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas

corresponding to the voxel; and, when the derived value for a voxel exceeds a threshold value:

(i) sub-dividing the voxel into subsidiary voxels;

(ii) determining the region corresponding to each sub-voxel in each image in which that sub-voxel is visible;

(iii) comparing characteristics of the image regions; and

(iv) removing the voxel only if there is no set of regions which contains a region from each image and for which the characteristics correspond.

Claim 92 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions to operate:

(a) to define an initial volume containing the object surface as an initial space formed of voxels;

(b) to access data representing images of the object recorded at different camera positions with respect to the object which data provides a colour value for each pixel of each image;

(c) to determine the area corresponding to a voxel in each image in which that voxel is visible;

(d) to determine a ~~colour~~ color space value for each pixel of each area where each ~~colour~~ color space value encompasses a range of pixel ~~colour~~ color values;

(e) to compare the ~~colour~~ color space values for each of the image areas corresponding to the same voxel; and

to remove the voxel only if the image regions do not share at least one ~~colour~~ color space value.

Claim 93 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions to operate:

(a) to define an initial volume containing the object surface as an initial space formed of voxels;

(b) to access data representing images of the object recorded at different camera positions with respect to the object;

(c) to determine the area corresponding to a voxel in each image in which that voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the same voxel; and

(e) to derive from the compared characteristics a

value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the voxel; and, when the derived value for a voxel exceeds a threshold value:

(i) to sub-divide the voxel into subsidiary voxels;

(ii) to determine the region corresponding to each sub-voxel in each image in which that sub-voxel is visible;

(iii) to compare characteristics of the image regions; and

(iv) to remove the voxel only if there is no set of regions which contains a region from each image and for which the characteristics correspond.

Claim 94 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions to operate:

(a) to define an initial volume containing the object surface as an initial space formed of voxels;

(b) to access data representing images of the object recorded at different camera positions with respect to the object which data provides a ~~colour~~ color value for each pixel of each image;

(c) to determine the area corresponding to a voxel in each image in which that voxel is visible;

(d) to determine a ~~colour~~ color space value for each pixel of each area where each ~~colour~~ color space value encompasses a range of pixel ~~colour~~ color values;

(e) to compare the ~~colour~~ color space values for each of the image areas corresponding to the same voxel; and

to remove the voxel only if the image regions do not share at least one ~~colour~~ color space value.

Claim 95 (currently amended): In an image processing system for processing image data defining images of an object to generate a three-dimensional computer model of the object by determining camera positions at which the images were recorded and by using the images and the camera positions to generate the three-dimensional computer model, an improvement comprising an apparatus for processing the image data to derive a computer representation of a three-dimensional surface of the object, the apparatus comprising a processor configured by processor instructions to operate:

(a) to define an initial volume containing the object surface as an initial space formed of voxels;

(b) to access data representing images of the object recorded at different camera positions with respect to the object;

(c) to determine the area corresponding to a voxel in each image in which that voxel is visible;

(d) to compare characteristics of each of the image areas corresponding to the same voxel; and

(e) to derive from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the voxel; and, when the derived value for a voxel exceeds a threshold value:

(i) to sub-divide the voxel into subsidiary voxels;

(ii) to determine the region corresponding to each sub-voxel in each image in which that sub-voxel is visible;

(iii) to compare characteristics of the image regions; and

(iv) to remove the voxel only if there is no set of regions which contains a region from each image and for which the characteristics correspond.

Claim 96 (currently amended): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions, the apparatus comprising:

a viewing volume determiner for determining the viewing volume for each camera position;

a bound volume determiner for determining the volume bounded by the intersection of the viewing volumes; and

an initial space setter for setting the bounded volume as an initial space for use in deriving a representation of a three-dimensional surface of the object using [[said]] the images.

Claim 97 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

a viewing volume determiner for determining the viewing volume for each camera position at which an image was taken;

a bound volume determiner for determining the volume bounded by the intersection of the viewing volumes;

a divider for dividing the bounded volume into voxels to form an initial voxel space; and

a processor operable:

(i) to determine, for a voxel that is not occluded by another voxel, the area corresponding to that voxel in each image in which that voxel is represented;

(ii) to compare characteristics of each of the image areas corresponding to the same voxel; and

(iii) to remove a voxel when the characteristics of the image areas corresponding to that voxel are inconsistent.

Claim 98 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

an initial volume determiner for defining an initial volume containing the object as an initial space formed of voxels, and

a processor operable:

(i) to access data representing a first set of images of the object each recorded at a respective one of a number of different camera positions with respect to the object;

(ii) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(iii) to compare characteristics of each of the image areas corresponding to the same voxel to remove any voxel have inconsistent characteristics and to store the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space;

(iv) then to access data representing a further image of the object recorded at a different camera position from the first set of images;

(v) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in the further image;

(vi) to compare the characteristic of the image area in the further image with the characteristic already associated with that voxel;

(vii) to remove any voxel for which the characteristic of the image area of the further image is inconsistent with that already associated with that voxel; and

(viii) to store the resulting voxel space as modified representation of the three-dimensional object surface.

Claim 99 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

an initial volume definer for defining an initial volume containing the object as an initial voxel space formed of voxels; and

a processor operable:

(i) to access data representing a first set of images of the object each recorded at a respective different one of a number of different camera positions with respect to the object;

(ii) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the first set of images in which that voxel is visible;

(iii) to compare characteristics of each of the image areas corresponding to the same voxel;

(iv) to remove any voxel having inconsistent characteristics and to store the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space;

(v) then to access data representing a second set of images consisting of a sub-set of the first set and a further image of the object recorded at a different camera position from the first set of images;

(vi) to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in each image of the second set;

(vii) to compare the characteristics of the image areas of second set;

(viii) to remove any voxel having inconsistent characteristics in the second set of images to store the resulting voxel space as an updated representation of the three-dimensional object surface.

Claim 100 (currently amended): In an image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

an initial volume definer for defining an initial volume containing the object surface as an initial space formed of voxels;

a data accessor for accessing data representing images of the object recorded at different camera positions with respect to the object; and

a processor operable:

(c) to check to see if a voxel meets at least one criterion by projecting that voxel into at least one of the images;

(d) if the voxel does not meet [[said]] the at least one criterion, to divide the voxel into subsidiary voxels; and

(e) then to check to see if the subsidiary voxels meets at least one criterion by projecting the subsidiary voxels into at least one of the images,

wherein the at least one criterion comprises any one or more of the following:

1) a color variance in a pixel patch to which the voxel projects in an image having a value lower than a predetermined value;

2) a difference in color or average color between pixel patches to which the voxel projects in different images having a standard deviation less than a predetermined value; and

3) the voxel is not partially occluded by a another voxel or subsidiary voxels of a smaller size than the voxel.

Claim 101 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

an initial volume definer for defining an initial volume containing the object surface as an initial space formed of voxels;

a data accessor for accessing data representing images of the object recorded at different camera positions with respect to the object; and

a processor operable:

(i) to determine the area corresponding to a given voxel in each image in which the voxel is visible;

(ii) to compare characteristics of each of the image areas corresponding to the given voxel;

(iii) to derive from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the given voxel;

(iv) to sub-divide a voxel into subsidiary voxels in response to the derived value exceeding a threshold value and to repeat steps (i) to (iii) for each subsidiary voxel;

(v) in response to a subsidiary voxel having a derived value exceeding a threshold value and a size greater than a minimum size, to sub-divide that subsidiary voxel into subsidiary voxels and to repeat (i) to (iii) for each subsidiary voxel of that subsidiary voxel;

(vi) to remove any subsidiary voxel of the minimum size having a derived value exceeding the threshold value; and

(vii) to repeat (i) to (vi) for each voxel that is not occluded by another voxel to provide a representation of the three-dimensional object surface consisting of the remaining non-occluded voxels and subsidiary voxels.

Claim 102 (currently amended): An image processing apparatus for processing image data representing images of an object taken from a plurality of different

camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

an initial volume definer for defining an initial volume containing the object surface as an initial space formed of voxels;

a data accessor for accessing data representing images of the object recorded at different camera positions with respect to the object which data provides a ~~colour~~ color value for each pixel of each image; and

a processor operable:

(a) to determine the area corresponding to a voxel in each image in which that voxel is visible;

(b) to determine a ~~colour~~ color space value for each pixel of each area where each ~~colour~~ color space value encompasses a range of pixel ~~colour~~ color values;

(c) to compare the ~~colour~~ color space values for each of the image areas corresponding to the same voxel; and

(d) to remove the voxel only if the image areas do not share at least one ~~colour~~ color space value.

Claim 103 (original): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions, a method of processing image data to derive a representation of a three-dimensional surface of the object, the apparatus comprising:

an initial volume definer for defining an initial volume containing the object surface as an initial space formed of voxels;

a data accessor for accessing data representing images of the object recorded at different camera positions with respect to the object; and

a processor operable:

(a) to determine the area corresponding to a voxel in each image in which that voxel is visible;

(b) to compare characteristics of each of the image areas corresponding to the same voxel; and

(c) to derive from the compared characteristics a value representing the degree of any inconsistency between the characteristics of the image areas corresponding to the voxel and, when the derived value for a voxel exceeds a threshold value,

(i) to sub-divide the voxel into subsidiary voxels,

(ii) to determine the region corresponding to each sub-voxel in each image in which that sub-voxel is visible,

(iii) to compare characteristics of the image regions, and

(iv) to remove the voxel only if there is no set of regions which contains a region from each image. and for which the characteristics are not inconsistent.

Claim 104 (currently amended): ~~Apparatus~~ An apparatus according to claim 41, wherein the processor means is operable to determine, for each voxel of the voxel space that is not occluded by another voxel, the area corresponding to that voxel in

each image in which that voxel is represented or visible by projecting the voxel into the image.

Claim 105 (currently amended): ~~Apparatus~~ An apparatus according to claim 41, wherein the processor means is operable to compare characteristics of each of the image areas corresponding to the same voxel by comparing the colours of each of the image areas.

Claim 106 (currently amended): ~~Apparatus according to claim 45~~ In an image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions to derive a representation of a three-dimensional surface of the object, the apparatus comprises:

means for defining an initial volume containing the object surface as an initial space formed of voxels;

means for accessing data representing images of the object recorded at different camera positions with respect to the object; and

processor means operable:

(a) to check to see if a voxel meets at least one criterion by projecting that voxel into at least one of the images;

(b) to divide, if the voxel does not meet the at least one criterion, the voxel into subsidiary voxels; and

(c) to check to see if the subsidiary voxel meets at least one criterion by projecting the subsidiary voxels into at least one of the images,

wherein the processor means is operable to compare characteristics of each of the image areas corresponding to the same voxel by comparing the ~~colours~~ colorsof each of the image areas.

Claim 107 (currently amended): ~~Apparatus~~ An apparatus according to claim 49, wherein [[the]] said processor means is operable to compare characteristics of each of the image areas corresponding to the same voxel by comparing the ~~colours~~ colors of each of the image areas.

Claim 108 (currently amended): ~~Apparatus~~ An apparatus according to claim 51, wherein [[the]] said processor means is operable to compare characteristics of each of the image areas corresponding to the same voxel by comparing the ~~colours~~ colors of each of the image areas.

Claim 109 (original): A method according to claim 72, further comprising, before step (g) , a step (f) of repeating steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space; and after step (j) a step (k) of repeating steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as an updated representation of the three-dimensional object surface.

Claim 110 (currently amended): A method according to claim 73, further[[,]] comprising, before step (g), a step (f) of repeating steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space; and after step (j) a step (k) of repeating steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as an updated representation of the three-dimensional object surface.

Claim 111 (original): A method according to claim 74, further comprising, before step (g) , a step (f) of repeating steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space; and after step (j) a step (k) of repeating steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as an updated representation of the three-dimensional object surface.

Claim 112 (original): A method according to claim 75, further comprising, before step (g), a step (f) of repeating steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space; and after step (j) a

step (k) of repeating steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as an updated representation of the three-dimensional object surface.

Claim 113 (currently amended): ~~Apparatus~~ An apparatus according to claim 76, wherein [[the]] said processor is operable to:

(f) repeat steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and storing the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space; and

(k) repeat steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed.

Claim 114 (currently amendedl): ~~Apparatus~~ An apparatus according to claim 77, wherein [[the]] said processor is operable to:

(f) repeat steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and store the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space and

(k) repeat steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed.

Claim 115 (currently amended): ~~Apparatus~~ An apparatus according to claim 78, wherein [[the]] said processor is operable to:

(f) repeat steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and store the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space; and

(k) repeat steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed.

Claim 116 (currently amended): ~~Apparatus~~ An apparatus according to claim 79, wherein [[the]] said processor is operable to:

(f) repeat steps (c) to (e) until all non-occluded voxels having inconsistent characteristics have been removed and store the resulting voxel space as a representation of the three-dimensional object surface, together with the characteristic associated with each non-occluded voxel of the resulting voxel space; and

(k) repeat steps (h) to (j) until all non-occluded voxels having inconsistent characteristics have been removed.

Claim 117 (currently amended): A method of operating an image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions, the method comprising the steps of:

(a) determining the viewing cone for each camera position;

(b) determining the volume bounded by the intersection of the viewing cones; and

(c) setting the bounded volume as an initial space for use in deriving a representation of a three-dimensional surface of the object using [[said]] the images.

Claim 118 (currently amended): An image processing apparatus for processing image data representing images of an object taken from a plurality of different camera positions, the apparatus comprising:

means for determining the viewing cone for each camera position;

means for determining the volume bounded by the intersection of the viewing cones; and

means for setting the bounded volume as an initial space for use in deriving a representation of a three-dimensional surface of the object using [[said]] the images.